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Review of the PhD thesis

titled

Techno-economical Comparison of Classical Activated Sludge Process and Cyclic Activated Sludge Technology used for the Biological Treatment of Wastewater

prepared by Konrad Falko Wutscher

I. The thesis characteristic

The reviewed thesis presents the comparison of two chosen wastewater treatment systems. The thesis structure is adapted to its character. The manuscript consists of 13 chapters plus Summary and References. There are also appendices added on CD. The first chapter presents a basic data about the history of wastewater treatment and the thesis aim, which is a comparison of two selected wastewater treatment systems – classical activated sludge and cyclic activated sludge technology in technical and economical aspects.

The second chapter presents data about EU law and wastewater treatment requirements as well as fundamentals and technological aspects of biological wastewater treatment. Then, in the third chapter, the Author shows the most known systems of biological wastewater treatment with nutrients removal dividing them into continuous flow systems, variable volume systems as well as suspended growth and attached biomass systems. In chapters 4 and 5 selected systems are described with their strengths, weaknesses, opportunities and threats.

In chapter 6 the postulate of the thesis is recalled and very brief methodology of the postulate verification is given. Chapter 7 shows the conditions chosen by the Author, allowing him to compare two treatment systems. The Author assumed that both systems fit for nutrients removal and can fulfill wastewater treatment standards. For exhaustible comparison the Author decided to include two dimensions of the system – a small and large treatment plant, two types of wastewater – diluted and non-diluted (coming from combined and separate sewerage networks respectively) and two types of soil –allowing for flat and deep foundation.

Chapter 8 comprises the dimensioning of the compared treatment plants with distinguished cases of a large and small treatment plant treating both diluted and non-diluted wastewater (depending on combined or separate sewerage network)

In chapters 9 and 10 the Author presents the estimation of investment and operation costs, respectively. Chapter 11 discusses other costs such as credits, loans and other financial aspects of the investment process.

Finally in chapters 11, 12 and 13 the Author presents financial analysis of the obtained results with the discussion and interpretation of the results allowing for positive verification of the thesis postulate.

The manuscript finishes with the summary and references.

II. The importance of the thesis subject

The requirements of wastewater treatment are growing in last decades. New processes are implemented for nitrogen and phosphorous removal due to the increasing demands of environmental protection and especially because of the eutrofication mitigation. In consequence the standards of treated wastewater are more and more severe. It results in growing prices of wastewater treatment and growing investment costs of new sewage treatment plants (STPs) and modernization of old ones. Moreover STPs operators are obliged not only to save energy by minimizing energy consumption, but also to transform STP in an enterprise producing energy for sale. For these reasons the choice of technology for wastewater treatment is a crucial issue having not only ecological but also financial consequences for the investors and STP operators. On the other hand this choice is complicated because many similar technologies offering comparable effectiveness of wastewater treatment is available. Therefore, the thesis presenting complex methodology allowing the techno- economical comparison of the chosen sewage treatment plants is interesting, especially for practitioners responsible for designing and maintaining STPs as well as for investors and decision makers in communities.

III. Values of the thesis

The Author of the thesis made the decision to show the advantages of chosen technology of wastewater treatment – cyclic activated sludge technology not by its ecological effects but by its techno-economical aspects. It is a rare attitude among doctoral candidates in environmental engineering that economical aspects are at least of the same importance as the ecological. The majority of the theses put stress on ecological efficiency of technology or process. Mr. K. F. Wutscher in his thesis postulated that both technologies chosen for comparison are comparable in their ecological effects and he looked for differences in the plants' dimensions and components and costs which resulted from technical solutions for each compared case. Chosen aspects of the comparison are also worth underlining. The Author compared both technologies taking into consideration the size of the treatment plant, character of the wastewater being a result of a sewerage network as well as soil conditions.

IV. Comments

The reviewed thesis has been written clearly. Thesis postulates, methodology and results have been presented in a logical way, easy to follow for a reader. Some specific remarks and opinions are listed below:

Subchapter 2.3 *Fundamentals of biological wastewater treatment*, page 21 – opinion about oxygen bound in nitrites and nitrates used for respiration during denitrification process is not a true. This opinion is presented in other pages too (p. 36,). In fact nitrogen from nitrites and nitrates plays a role of electrons acceptor within denitrification, not oxygen.

Subchapter 2.3.5 *Plug flow reactor PFR*, page 29, Fig. 2.10 – the Author's opinion about the cascade system's advantage over CSTR basing on the results presented in Fig. 2.10 goes too far. Cascade system manages to buffer the surge load better only to some extent. At higher loads a stirred reactor gives lower effluent concentration.

Subchapter 4.2.3.2 *Cascade denitrification system*, page 60 – described the weakness of the system – *Changing load patterns affect the system performance* – is not clear for all readers. Author should explain what it means.

Subchapter 4.2.4 *Description of CASP type processes for nitrogen and phosphorous removal*, page 63, *Weaknesses* and page 64, *Opportunities* – PHB is not a specific substrate supplied, as the Author wrote. PHB is formed in the cells of PAOs. In fact volatile fatty acids VFA are supplied for PHB formation in cells and they can be produced by primary sludge fermentation.

Subchapter 8.2.1 *Results of dimensioning of CASP. Diluted wastewater CASP*, Fig. 8.4 – the total volume of the bioreactor has been badly calculated. It is 17.144 m³ but it should be 15.425 m³. The Author should explain how this fault impacts the thesis results.

Subchapter 8.2.2 *Results of dimensioning of CASP. Non -diluted wastewater CASP*, Fig. 8.5 – the Author should explain why the volume of anoxic zone is a bit larger than the aerobic zone of the reactor. Usually the volume of the anoxic zone amounts to about 30% of the volume of aerobic zone. This rule is kept in case of CASP treating diluted wastewater (Fig. 8.4).

Subchapter 9.1 *Estimation of investment costs CAPEX. Methodology*, page 114, Fig. 9.1 and 9.2 – the conclusion about CYC plants, that they are statistically more economic in terms of CAPEX costs, is true only for small STPs without sludge digestion. In case of sludge digestion being a part of STPs the conclusion is true only for STPs no bigger than 200 000 pe.

Minor comments concern the editing of the thesis.

In many places of the text the marks of references are missing. A table of contents does not have the numbers of pages. Tables are named wrongly as figures. Many figures, for example figures 2.9, 2.11, 2.12, 9.3, are described in German or the units are in German language or units are missing. Some figures, for example 2.12, 2.13, 5.12, 5.14, are not cited in the manuscript. Some units and parameters are written without necessary subscripts, superscripts,

exponents, ect. Untypical construction of references makes difficulties in accessing the used sources. Less important errors are not mentioned here. They have been marked in the text and passed to the Author. All these remarks reflects on the small experience of the Author in preparation of the scientific publications.

V. Final conclusion

By his thesis Mr. Konrad F. Wutscher showed his ability to form the scientific problems and to solve them using proper methodology. He proposed complex methodology for the comparison of the treatment plants in technical and economical terms.

Therefore in my opinion the reviewed thesis titled *Techno-economical Comparison of Classical Activated Sludge Process and Cyclic Activated Sludge Technology Used for the Biological Treatment of Wastewater* fulfills the requirements of the *Law on Academic Degrees and Title and Degrees and Title in the Arts* and concluding I propose to admit it to public defense.



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